The agenda for CS286 lecture #14 (October 10, 2022):

1. Pick up:
   - Attendance card

2. Quiz #6 has been graded

3. Midterm exam
   - Programming projects
   - CAT-II and CAT-III questions will contain CAT-I components

4. Exercise Questions (#4 and #5 on September 21st)

**QUESTION #4**

Let us assume that we have two processors (Processor A and B). The clock cycle rate and CPI of Processor A are:

**Processor A:**  
Clock cycle rate = 900 MHz.  
CPI = 1.2

The CPI of Processor B is:

**Processor B:**  
CPI = 0.7

The two processors have different instruction sets. The average IC for processor A is expected to be 25% smaller than that of Processor B. In order for Processor B to perform at least as fast as Processor A, what should be the clock cycle rate for Processor B?

**EXERCISE #5**

- Questions (1), (2), and (3) for your homework
- If you try them, I am willing to check them in the CS286 office hour tomorrow (10/11).

5. Four Data Hazards
   - What is “pipeline hazard”?
   - What is “data hazard”?
   - How can “data hazard” occur in four different ways
   - What is “control hazard”?  


QUESTION #6

Suppose the branch frequencies (as percentage to all the instructions) are as follows:

- Conditional branches: 11%
- Jumps and calls: 4%
- Conditional branches: 55% are taken

We are examining a ten-phase pipeline processor, in which different instructions require different number of processor cycles to complete (as shown below). Assume that each conditional branch requires eight cycles to complete (the decision of a conditional instruction is made available at the end of the eight cycle). Similarly, each unconditional branch requires six cycles to complete (the decision of an unconditional instruction is made available at the end of the sixth cycle). All other instructions require exactly ten cycles to complete.

Questions: Assuming that only the first pipe stage can always be done independent of whether the branches goes and ignoring other pipeline stalls, (a) how much faster would the machine be without any branch hazards? (b) If the pipeline becomes deeper, what would you expect for the speed up? For (a), show all your work.